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The Role of Stocks in World Grain Market Stability

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Abstract

The world's grain stocks have provided the world's consumers with more stable supplies in recent years than in the 1960's and 1970's. In recent years, U.S. grain stocks played a major role in reducing the variability of world grain prices. Stocks in the European Community, Canada, and India also provided some stability. The former Soviet Union and Argentina were major sources of instability in world grain markets. Results of this study suggest that economists need to examine the implications of future reductions in stock levels, the possible result of policy changes, and trade liberalization.

Keywords: Coarse grains, global grain stocks, international trade, price variability, wheat

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Summary

Previous studies of world stocks, based on data from the 1960's and 1970's, concluded that world grain price variability was excessive due to suboptimal management of the world's grain stocks. Results from this study indicate, however, that in more recent years, world grain markets appear to be doing a better job than earlier in allocating the world's grain from one year to the next. Evidence of this is (1) less year-to-year variability around trends in global grain consumption, even though world production variability has increased, and (2) less variability of season average world grain prices.

To understand how the world's stocks are managed, one needs to examine stocks management in those countries that hold most of the world's grain stocks--the major producers. Analyses showed the following:

- Grain stocks in the United States were a major stabilizing force on world grain markets. Massive adjustments in U.S. grain stock levels offset large domestic grain production variability. Further, U.S. stocks were very responsive, in a stabilizing way, to world grain price movements.

- Production variability in the former Soviet Union is a major source of potential instability to world grain markets. The restructuring of the former Soviet Union, because of its size, could have a significant effect on the stability of world grain markets.

- Argentina also is a major potential source of instability to world grain markets. Historically, few stocks have been carried in Argentina, and no measurable adjustments have appeared to be made in Argentine domestic grain stocks to provide any stability to world grain markets.

- Stock adjustments made in the European Community (EC) in recent years appear to contribute significantly to world grain market stability. This conclusion differs from that of previous studies.

- Wheat stocks in India and Canada also appear to have added stability to the world market.

Recent U.S. policy changes could lead to the United States playing a reduced role in stabilizing world grain markets. Because of the dominant role of the United States in stabilizing world grain markets, these policy changes could be very significant to all countries that participate in these markets.

Results of this study also suggest that more research is needed to test whether trade liberalization might lead to a reduction in year-to-year variability in world grain prices, compared with that observed in recent years.

The Role of Stocks in World Grain Market Stability

Jerry Sharples
Steve Martinez

Introduction

In the late 1970's and early 1980's, many studies examined world grain market stability and grain stocks issues (Houck and Ryan, 1979; Blandford, 1983). These studies were in response to grain shortages and the increase in grain market variability in the 1970's, and generally concluded that world grain price variability was excessive due to suboptimal management of the world's grain stocks. Further, the forces creating that variability were not expected to diminish. Various national and multinational solutions were proposed either to improve management of stocks or to reduce other destabilizing forces affecting world grain markets. Several studies further suggested that only a few countries--mainly the United States--used their grain stocks in a way that would add stability to world grain markets (Josling, 1980; Sharples and Goodloe, 1984).

As global grain stocks grew in the 1980's, interest in the topic waned. In the early 1990's, however, interest in market stability and grain stocks was rekindled. There were two main reasons for the renewed interest. The first reason was the sharp drop in world grain stocks (fig. 1). World wheat and coarse grain stocks dropped to 18 percent of world use in marketing year (MY) 1989, near the record low of 16 percent in MY 1973 (fig. 2). The second reason was the discussion of actual and potential policy changes that could change stockholding behavior of governments and individuals around the world. Examples of the latter were the new farm legislation in the United States and the General Agreement on Tariffs and Trade (GATT) negotiations to reduce agricultural protection and liberalize trade. This renewed interest led to a session on global stocks at the Tokyo meetings of the International Association of Agricultural Economists in 1991 (Reinsel, 1993).

In this report, we use more recent data to reexamine the role of stocks in world grain market stability. In particular, we look at stability that stocks have added to world grain markets since the late 1970's. World aggregate grain data are first compared for two periods, 1960-77 and 1978-91.[1,2] The evidence suggests that stocks adjustments more effectively enhanced world market stability in the more recent period. Then we examine country data to determine which country's grain stocks provided that added stability.

This report focuses on how stocks have performed on world grain markets. It does not examine in detail the market forces and policies of key countries that caused the observed stocks behavior. That topic is worthy of additional research.

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[1] In this report, grain refers to wheat and coarse grains. Rice is omitted because the world rice market is quite thin, and rice stocks play a less prominent role in world grain markets.

[2] The main reason for examining two time periods is to look for evidence that stocks behavior has changed in more recent years. The periods compared are somewhat arbitrary; a major reason for splitting the data after 1977 is that the European Community (EC) became a net exporter of grain at about this time. As results from this study show, substantial changes in the EC's stocks behavior occurred when it became a net exporter of grain.

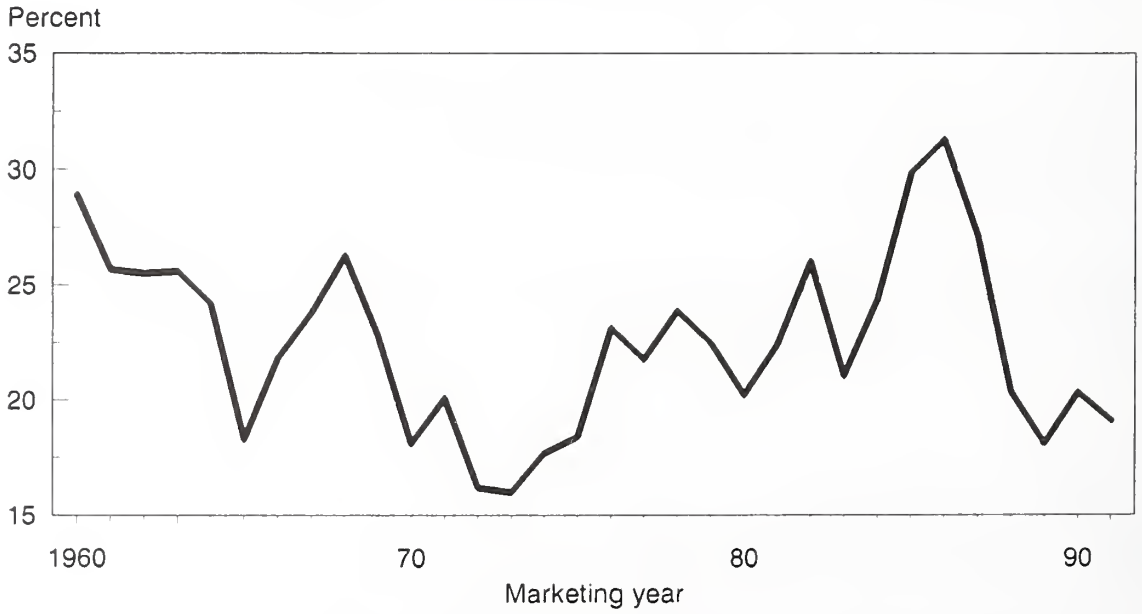
Figure 1

World grain stocks, 1960-91

Source: Webb and Gudmunds, 1991.

Figure 2

World grain stocks as a percentage of consumption, 1960-91



Source: Webb and Gudmunds, 1991.

The Global Picture

Evidence since the late 1970's suggests that the world's grain stocks are doing a better job of protecting consumers from the year-to-year variability of the world's grain production (table 1). One measure of stocks performance is to compare the variability of global grain consumption with the variability of global grain production. Consumption variability that is less than production variability demonstrates that adjustments of end-of-year grain stocks reduced the effects of production variability on consumers.

The variation of world wheat production deviations from trend, as measured by standard error, was 16.7 million tons (5 percent of total wheat production) during the 1960-77 period (table 1). The standard error of consumption in those years was 10.4 million tons (3 percent of total wheat consumption). The world's wheat stocks thus helped stabilize grain consumption. From 1978 to 1991, the standard error of global wheat production increased to 19.6 million tons (4 percent of wheat production), but the standard error of global wheat consumption declined to 8.1 million tons (2 percent of wheat consumption), evidence that the world's wheat stocks provided even more protection to consumers than in the earlier years.

Table 1--Measures of annual dispersion from trends in world wheat and coarse grain price, production, and consumption over specified years

Item	Unit	1960-77	1978-91
Wheat production:			
Standard error[1]	Mil. tons	16.7	19.6
Coefficient of variation[2]	Percent	5.3	3.9
Wheat consumption:			
Standard error	Mil. tons	10.4	8.1
Coefficient of variation	Percent	3.3	2.0
Wheat price:[3]			
Standard error	U.S. $/ton	29.4	19.9
Coefficient of variation	Percent	34.0	13.5
Coarse grain production:			
Standard error	Mil. tons	17.9	40.6
Coefficient of variation	Percent	3.2	5.2
Coarse grain consumption:			
Standard error	Mil. tons	14.8	9.8
Coefficient of variation	Percent	2.6	1.3
Coarse grain price:[4]			
Standard error	U.S. $/ton	17.5	17.7
Coefficient of variation	Percent	24.5	15.7

[1] Standard error of deviations from trend.

[2] Coefficient of variation (CV) is calculated by dividing the standard error by the mean and multiplying the result by 100. CV is a unitless measure of dispersion that removes the effect of production levels on variability.

[3] U.S. gulf free on board (f.o.b.) hard red winter (ordinary) wheat price.

[4] U.S. gulf f.o.b. corn price (no. 2).

Sources: Production and consumption were obtained from Webb and Gudmunds, 1991. Prices were obtained from Wheat: Situation and Outlook Yearbook (USDA), various issues, and Feed: Situation and Outlook Yearbook (USDA), various issues.

In the 1960-77 period, coarse grain stocks were not nearly as effective in stabilizing global coarse grain consumption as wheat stocks were in reducing the year-to-year variability of global wheat consumption. The standard error of production for coarse grains was 17.9 million tons, and the standard error of consumption was 14.8 million tons. The reason for more variability of coarse grain consumption likely relates to the fact that livestock rather than people are the major consumers of coarse grains. Livestock numbers and feeding rates can be more easily adjusted to the grain supply. Since 1978, however, the world's coarse grain stocks have been extremely effective in offsetting a large increase in production variability. The standard error of production more than doubled to 40.6 million tons (5 percent of coarse grain production) since 1978, but the standard error of consumption dropped to 9.8 million tons (1 percent of coarse grain consumption).

Another measure of market variability is the deviation around trends in the annual average prices at which grain is traded. The data have shown a significant reduction in the variability of world wheat and coarse grain prices since 1978, as measured by the coefficient of variation (table 1). Economists suggest that reduced price variability may result from either improved management of the world's stocks, or from other forces, such as a reduction of trade barriers (Grennes, Johnson, and Thursby, 1978).[3]

Stocks Behavior: Selected Countries

The rules for managing the world's grain stocks are set by firms and governments in countries. There is no explicit global strategy. To understand the behavior of the world's stocks, one needs to examine stocks behavior in the major grain stockholding countries. Two questions guide our examination of country data. The first question is: To what extent do major grain producing countries use yearend stocks in a way that offsets their own production variability? An associated issue is: To what extent do these countries pass domestic production variability on to the world market and make it more volatile? The second question is: To what extent do these countries adjust their grain stocks to absorb some of the grain market variability generated by other countries? Results of our examination show which countries tend to be the major sources of world grain market variability, and which countries adjust their stocks in a way that adds stability to the world market.

Previous studies have suggested that the former Soviet Union[4] is the most important potential transmitter of production variability to the world grain market (Sharples and Goodloe, 1984; Blandford, 1983). Studies also showed that the United States (and to a lesser extent, Canada and several other countries) contributed to world market stability through stock adjustments. Grain stocks in the European Community (EC) made no noticeable contribution to world grain market stability (Sharples and Goodloe, 1984; Blandford, 1983; Josling, 1980).

A report by Sharples and Krutzfeldt (1990) gave an overview of which countries were the world's major holders of grain stocks in the late 1980's, and how those stocks were used. They concluded that, as in earlier years, the United States still held most of the world's buffer stocks (that is, stocks available to help stabilize the world market).

The country analysis reported here is a more quantitative followup to the Sharples-Krutzfeldt report. Using revised methods and more recent data, we examine the major conclusions of reports of the late 1970's and early 1980's, and find that some conclusions need to be revised.

We proceed by separately examining the wheat and coarse grains stocks behavior in selected countries. Stocks behavior differs between the two types of grain. We also compare more recent

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[3]The term "management" in this report does not imply that stocks are adjusted with any particular objectives in mind. Adjustments in stocks may simply be an outgrowth of domestic policies.

[4]We refer collectively to the republics of the former USSR as "former Soviet Union."

behavior, based on 1978-91 data, with that observed in earlier years (1960-77) to identify evidence of change in a country's grain stocks management strategies. Examining differences between the two time periods may provide insight into how policy changes have affected stock adjustments. Relating observed stockholding behavior to country policies or examining optimal stockholding, however, are topics for further exploration in another report.[5]

Stocks Adjustments and Domestic Production Variability

Year-to-year variability in grain production is a major source of instability of a country's grain supply. When any major grain producing country has an unusually large or small harvest, it can adjust to that shock in any of three ways: by adjusting either domestic grain consumption, the amount of grain stocks carried over to next year, or the quantity imported or exported. A country's choice of action could have a significant effect on the stability of both the domestic and world grain markets.

For example, suppose that an importing country had an unusually poor wheat harvest one year. That country might cut back on consumption and/or reduce its carryover stocks to fully absorb the effects of the poor domestic harvest. On the other hand, the country could completely export its production shock onto the world market by maintaining trend consumption and stock levels, and by increasing wheat imports to offset the poor harvest. Conversely, when the harvest was above normal, that country could consume more and also build up ending stocks, or could simply reduce imports. A country's strategy of relying fully on the world market to offset its own production variability would force other countries to absorb its production shocks. This likely would add instability to the world market.

Coarse grain data over the last 30 years for India, Argentina, and the United States illustrate extreme cases of each of the three possible ways a country can absorb its own production shocks. In India, practically all coarse grain production is consumed at home. Coarse grain consumption in India varies from year to year in direct response to changes in production (fig. 3), but there is very little variability from one year to the next in trade or yearend stock levels. India apparently did not use trade or adjustments in coarse grain stocks to offset production variability. One can infer that India's policies that created this pattern of coarse grain trade led to barriers preventing export of India's production shocks to the rest of the world.

Argentina exhibits large production variability (fig. 4), most of which is passed on to the international market. Coarse grain consumption in Argentina is moderately stable. Argentina maintains a very low level of grain stocks that are not used to smooth out supplies from one year to the next. Argentina instead goes to the world market, rather than its own stocks, to help reduce consumption variability. This practice could contribute to world market instability.

In the United States, coarse grain production has been highly variable since the late 1970's, but consumption has been considerably less variable due to offsetting stocks adjustments (fig. 5). The magnitude of year-to-year changes in both U.S. production and stocks in the 1980's is huge by world standards. However, the production shocks did not cause large changes in coarse grain exports. U.S. stocks, rather than the world market, absorbed most of the production variability.[6]

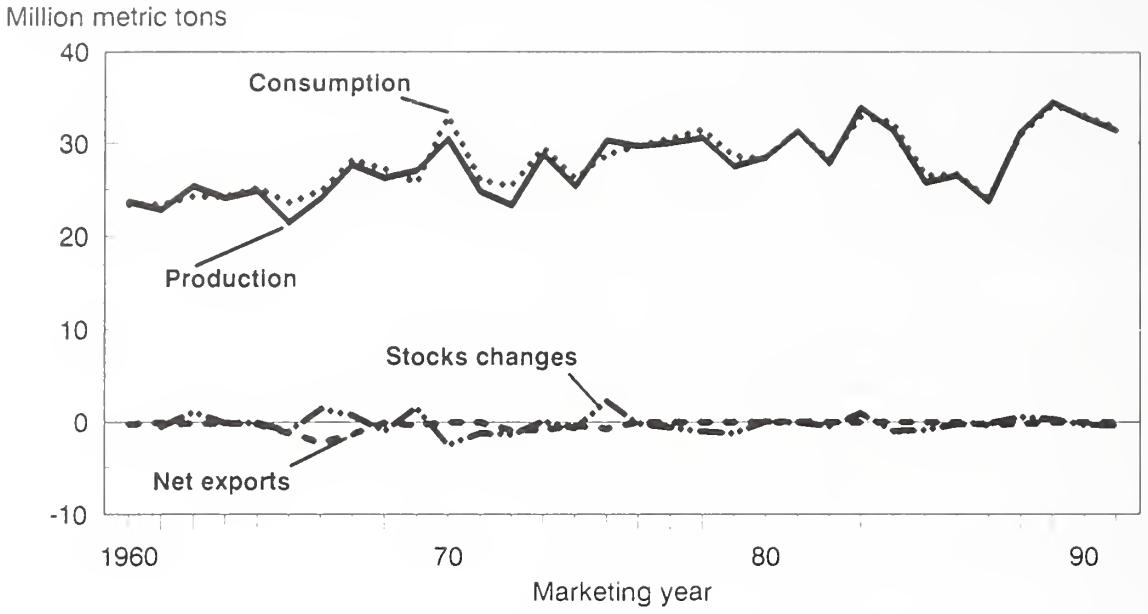
Examples of these three countries indicate that they each pursued different coarse grain policy strategies. Argentina's year-to-year changes in production have been a source of world grain market

[5]See Gardner (1979), Plato and Gordon (1983), and Williams and Wright (1991) for a detailed discussion of the theory behind optimal stock levels, and for a thorough reference listing of literature on this subject.

[6]The fact that net exports showed little variability, however, does not mean that U.S. production variability failed to generate instability on the world market. World prices reacted to the large fluctuations in the quantity of coarse grain supplies that were available for export from the United States.

Figure 3

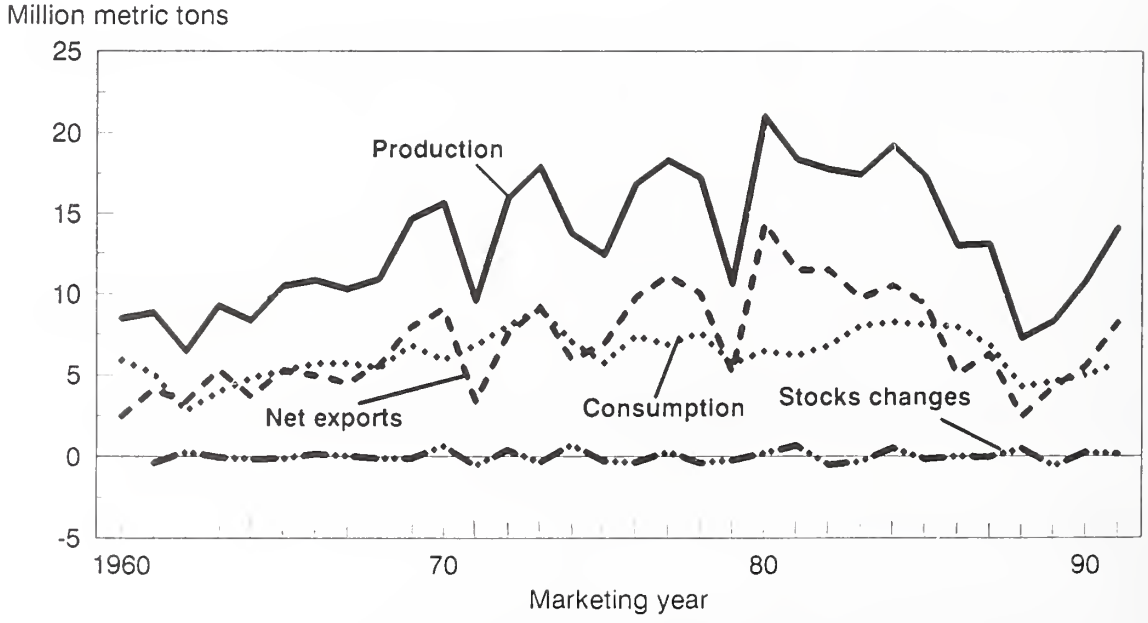
India's coarse grains, 1960-91



Source: Webb and Gudmunds, 1991.

Figure 4

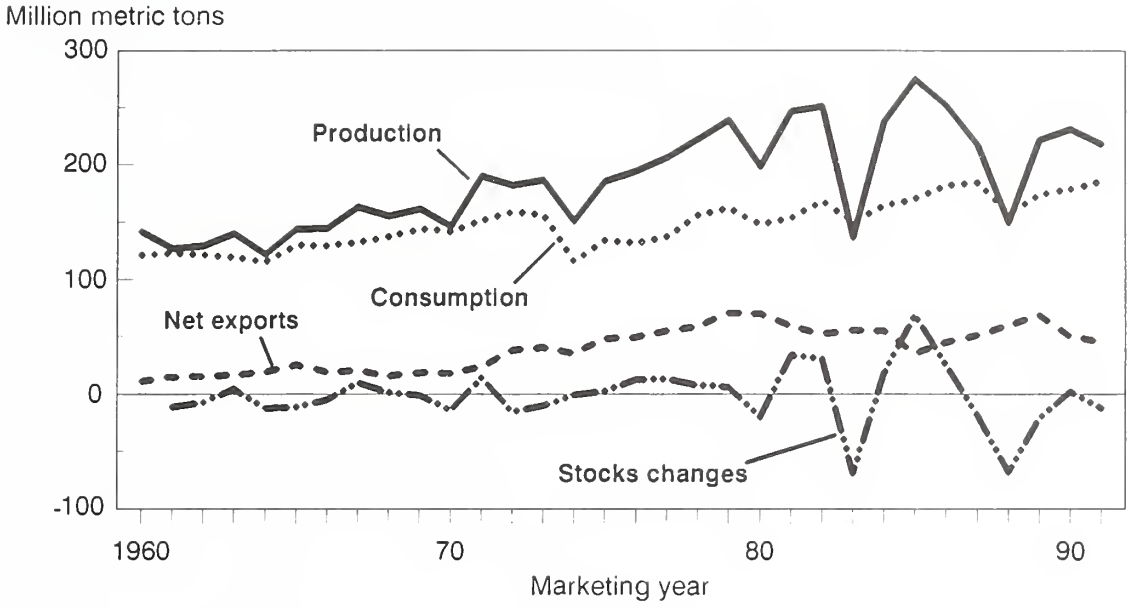
Argentina's coarse grains, 1960-91



Source: Webb and Gudmunds, 1991.

Figure 5

U.S. coarse grains, 1960-91



Source: Webb and Gudmunds, 1991.

variability, while India and the United States passed on relatively little of their production shocks to the world market. Stocks absorbed production shocks in the United States. India represents a rare case where consumption rather than stocks absorbed most of its production shocks; when production declined, so did consumption.

Most major grain producing countries attempt to stabilize their grain consumption. If domestic stocks do not adjust to offset their own production shocks, then trade usually adjusts. Therefore, a country that does not adjust stocks may be transmitting domestic production variability to the world market. In this way, the tradeoff between stocks and trade adjustments becomes linked to world grain market stability.

Adjustments to Domestic Production Shocks

For most major grain producing countries, adjustments to production shocks are not as obvious as in the above examples. However, simple regressions can be used to suggest how countries have responded to domestic production shocks. The following equations were estimated for each major grain producing country for each of the two time periods, 1960-77 and 1978-91:

$$C = (a_1 * Q) + e_1, \quad (1)$$

$$T = (a_2 * Q) + e_2, \quad (2)$$

$$S = (a_3 * Q) + e_3, \quad (3)$$

where Q is the change in production[7] from the previous year, C is the change in domestic use, T is the change in net exports (exports minus imports), and S is the adjustment in stocks.[8] Specifying the equations in this manner forces the equality, $a_1 + a_2 + a_3 = 1.0$, which is convenient for comparison purposes. A larger a_i coefficient suggests greater adjustments in response to production shocks. Specifically, if the a_2 coefficient is large, this implies that a large share of production shocks is exported. Production shocks, if exported, could add more instability to the world market. Estimates of the coefficients in the production-shock-absorption equations, (1) to (3), are presented in tables 2 (wheat) and 3 (coarse grains).

Wheat Production Shocks. Since 1978, the former Soviet Union has had by far the largest wheat production variability of any country or region, as measured by standard error (table 2, column 2). The United States is second, and China is third. After removing the effect of crop size, however, Argentina, Australia, and Canada have the most production variability (column 3). Note also the low production variability since 1977 in India and Turkey.

Results from estimating equations 1, 2, and 3 for each country or region are presented in the last three columns of table 2. Estimates for the United States for 1978-91 illustrate how the numbers may be interpreted. On the average during that period, changes in domestic wheat consumption absorbed 19 percent of the year-to-year variability in U.S. wheat production, trade absorbed 9 percent, and adjustments in yearend stocks absorbed 72 percent. These numbers mean that stocks adjustments offset most of the variability of U.S. wheat production. Stocks adjustments protected U.S. consumers and the world market from domestic production variability.

The results show that major grain producers tend to protect their consumer markets from domestic production variability, as indicated in table 2 by the small coefficients for domestic use. Eastern Europe is a major exception. The lower income countries of India, Mexico, and China also exhibit a tendency for their consumers to absorb a higher proportion of domestic production variability.

In recent years, trade has been used to absorb much of the production variability in Argentina, Turkey, South Africa, Mexico, Canada, and Australia (see the coefficients for trade in table 2). At the other extreme, trade has not been used by India in recent years to offset the variability of domestic wheat production.

Most of the major wheat producing countries use end-of-year stock adjustments to offset at least part of their domestic production variability (see the coefficients for stocks in table 2). For example, the former Soviet Union, which has to contend with highly variable production, apparently uses wheat stocks to offset a large portion of that variability.[9] Wheat stocks in Eastern Europe and Argentina, however, absorbed very little of their own production variability in recent years.

Some significant changes have occurred since 1977 in how countries respond to their own wheat production variability. Stocks have become more important in offsetting production variability in the EC and in India, and less important in Canada, Eastern Europe, Turkey, and the United States.

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[7] Similar equations were estimated for 1960-82 in Sharples and Goodloe (1984). However, they used supply (production plus beginning stocks) rather than production as the independent variable. Using supply provided ambiguous results for major stockholding countries because volatility of beginning stocks would affect the results.

[8] S measures the difference between the change in stocks in the current period and the change in stocks in the previous period. Specifically:

$$S_t = (E_t - B_t) - (E_{t-1} - B_{t-1}),$$

where E is ending stocks, and B is beginning stocks.

[9] One must discount conclusions that are drawn from grain stock numbers for the former Soviet Union and China. Their stock numbers represent total stocks in the country and are subject to substantial error.

Table 2--The allocation of domestic wheat production shocks for the major stockholding countries or regions, 1960-77 and 1978-91

Country or region	Production			Share of production deviations absorbed by:		
	Average	Standard error[1]	CV[1]	Domestic use (a_1)	Trade (a_2)	Stocks (a_3)
	Million metric tons		Percent	Fraction		
Former Soviet Union:						
1960-77	81.7	13.9	17	0.09	0.25	0.66
1978-91	89.5	13.8	12	.15	.20	.65
China:						
1960-77	29.7	3.3	11	.20	.23	.57
1978-91	78.5	6.1	6	.25	.22	.53
United States:						
1960-77	41.6	4.0	10	.04	-.21[2]	1.17
1978-91	62.4	9.6	15	.19	.09	.72
EC-12:						
1960-77	42.8	3.4	8	.22	.35	.43
1978-91	73.0	4.9	7	.11	.29	.60
Eastern Europe:						
1960-77	25.3	1.9	7	.51	.27	.22
1978-91	34.5	2.9	8	.70	.24	.06
India:						
1960-77	17.9	2.6	14	.40	.38	.22
1978-91	42.9	2.4	6	.41	.02	.57
Canada:						
1960-77	16.3	4.0	24	.02	.16	.82
1978-91	24.1	4.4	18	.04	.47	.49
Australia:						
1960-77	9.6	2.2	23	0	.34	.66
1978-91	15.1	3.5	23	-.07	.47	.60
Turkey:						
1960-77	8.8	1.2	14	.19	.22	.59
1978-91	13.7	.9	7	.01	1.03	-.04
Argentina:						
1960-77	6.8	2.0	29	0.22	0.73	0.05
1978-91	9.9	2.3	23	.05	.97	-.02
Mexico:						
1960-77	2.0	.3	15	.15	.60	.25
1978-91	3.5	.6	18	.23	.54	.23

See footnotes at end of table.

Continued--

Table 2--The allocation of domestic wheat production shocks for the major stockholding countries or regions, 1960-77 and 1978-91--Continued

Country or region	Production			Share of production deviations absorbed by:		
	Average	Standard error[1]	CV[1]	Domestic use (a_1)	Trade (a_2)	Stocks (a_3)
	Million metric tons		Percent	Fraction		
South Africa:						
1960-77	1.3	.2	15	.09	.67	.24
1978-91	2.2	.6	25	0	.64	.36
World:						
1960-77	312.8	16.7	5	.19	--	.81
1978-91	497.1	19.6	4	.36	--	.64

– = Not applicable. There is no net trade at the world level.
[1]See definitions in table 1.
[2]A negative coefficient results from year-to-year changes in exports being negatively correlated with corresponding changes in production.

Coarse Grain Production Shocks. The United States dominates the coarse grain market. More than twice as much coarse grains are produced in the United States than in any other country, and in recent years, the biggest shocks to global production have come from the United States. Note that the standard error of coarse grain production for the United States was 39.8 million tons since 1978, but only 12.5 million tons for the rest of the world (table 3).

During the 1960-77 period, domestic use absorbed about half of the production variability in the United States. Stock adjustments absorbed much of the remainder. Since 1977, however, stocks have played a very important role in absorbing the extreme production variability. Results indicate that over the last 30 years, the United States has not tended to export its production shocks.

Results for the United States have to be interpreted somewhat differently than those for other countries. To a significant extent, grain production responds to stock levels. For example, the payment-in-kind government program of 1983 lowered production to reduce the record-high level of U.S. grain stocks. There is thus a strong two-way linkage between U.S. production and stocks. In other countries, a one-way linkage is assumed, wherein stock levels may adjust in response to quantities produced.

The former Soviet Union has the second-largest standard error of production (table 3). Results show that in the most recent period, domestic use absorbed much less of Soviet production variability. The Soviets turned to the export market, and not to stocks, to provide more stability for consumption.

China, the EC, and Eastern Europe have exhibited low absolute and relative levels of coarse grain production variability since 1960. Their stocks coefficients in table 3 indicate increased use of stocks to absorb domestic production shocks since 1978/79.

Global Aggregate Stocks Adjustments

At the global level, there are only two ways for the world as a whole to respond to year-to-year changes in grain production: by adjusting either consumption or carryover stocks. Results since the late 1970's show that the world's wheat consumers absorbed about 36 percent of year-to-year

Table 3--The allocation of domestic coarse grain production shocks for the major stockholding countries or regions, 1960-77 and 1978-91

Country or region	Production			Share of production deviations absorbed by:		
	Average	Standard error[1]	CV[1]	Domestic use (a_1)	Trade (a_2)	Stocks (a_3)
	Million metric tons		Percent	Fraction		
United States:						
1960-77	159.5	13.3	8	0.47	0.16	0.37
1978-91	222.6	39.8	18	.19	-.05	.86
Rest of world:[2]						
1960-77	400.4	13.6	3	.74	.05	.21
1978-91	558.9	12.5	2	.58	.01	.41
Former Soviet Union:						
1960-77	72.3	11.4	16	.61	.22	.17
1978-91	97.0	10.6	11	.32	.57	.11
China:						
1960-77	54.2	4.0	7	.63	.02	.35
1978-91	89.3	4.8	5	.35	.06	.59
EC-12:						
1960-77	61.0	4.3	7	.33	.56	.11
1978-91	88.8	5.1	6	.30	.26	.44
Eastern Europe:						
1960-77	48.9	2.6	5	.79	.08	.13
1978-91	58.5	4.1	7	.31	.26	.43
India:						
1960-77	26.1	2.1	8	.87	0	.13
1978-91	30.1	3.4	11	.87	.01	.12
Canada:						
1960-77	17.0	2.2	13	.35	.19	.46
1978-91	23.1	2.5	11	.06	.25	.69
Argentina:						
1960-77	12.2	2.0	16	.22	.73	.05
1978-91	14.4	3.5	24	.16	.82	.02
Mexico:						
1960-77	9.9	0.9	9	0.43	0.46	0.11
1978-91	14.3	1.7	12	.26	.81	-.07
South Africa:						
1960-77	7.6	1.9	25	.05	.45	.50
1978-91	9.0	2.9	32	.02	.58	.40

See footnotes at end of table.

Continued--

Table 3--The allocation of domestic coarse grain production shocks for the major stockholding countries or regions, 1960-77 and 1978-91--Continued

Country or region	Production			Share of production deviations absorbed by:		
	Average	Standard error[1]	CV[1]	Domestic use (a_1)	Trade (a_2)	Stocks (a_3)
	Million metric tons		Percent	Fraction		
Australia:						
1960-77	3.8	.8	21	.22	.52	.26
1978-91	6.9	1.3	19	.03	.81	.16
Turkey:						
1960-77	6.2	.6	10	.68	.02	.30
1978-91	8.5	.7	8	.08	.50	.42
World:						
1960-77	559.9	17.9	3	.70	--	.30
1978-91	781.6	40.6	5	.18	--	.82

-- = Not applicable. There is no net trade at the world level.
[1]See definitions in table 1.
[2]World excluding United States.

production variability, and ending stocks absorbed the rest (table 2). Thus, stocks provided to the world's wheat consumers substantial, but far from complete, protection from production shocks.

An analysis of world totals for coarse grains after 1977 shows (1) a substantial increase in the variability of production, and (2) a greater importance of stocks adjustments in absorbing production shocks. These global results for coarse grains were mainly caused by events occurring in the United States.

Though different analytical methods were used, these world total conclusions, drawn from tables 2 and 3, appear to be consistent with the results in table 1 for 1978-91. The world results for wheat in table 2 suggest that consumers absorbed more of the world's wheat production variability after 1977, which appears to contradict findings in table 1. Recall, however, that inherent variability of wheat production and consumption (as measured by the coefficient of variation) both fell, suggesting that wheat stocks did not necessarily provide more protection against inherent variability in production.

Quantifying Transmission of Production Shocks

To estimate the magnitude of a country's production variability that is transmitted to the world market, multiply the standard error of domestic production by the fraction absorbed by domestic trade (from tables 2 and 3). The results (table 4) provide an estimate of the extent to which countries contributed to variability in the world market. The estimate is large if domestic production variability is high and/or if relatively large adjustments in trade occur in response to changes in domestic production.

The former Soviet Union, Argentina, the United States, the EC-12, Canada, and Australia were major sources of shocks to the world grain market. Consistent with earlier studies, results show that the former Soviet Union (a major grain importer) transferred the most domestic production variability onto the world wheat market. The standard error of wheat production in the former Soviet Union was relatively large compared with that in other major producing countries. For this reason, the Soviet

Table 4--Standardized annual domestic production shocks transferred to the world grain market, 1960-77 and 1978-91[1]

Country or region	Wheat		Coarse grains		Total[2]	
	1960-77	1978-91	1960-77	1978-91	1960-77	1978-91
	Million tons					
Former Soviet Union	3.5	2.8	2.5	6.0	6.0	8.8
Argentina	1.5	2.2	1.5	2.9	3.0	5.1
United States	.8[3]	.9	2.1	2.0	2.9	2.8
EC-12[4]	1.2	1.4	2.4	1.3	3.6	2.7
Canada	.6	2.1	.4	.6	1.0	2.7
Australia	.7	1.6	.4	1.0	1.1	2.7
South Africa	.1	.4	.8	1.7	.9	2.1
Eastern Europe[4]	.5	.7	.2	1.1	.7	1.8
Mexico	.2	.3	.4	1.4	.6	1.7
China	.8	1.3	.1	.3	.9	1.6
Turkey	.3	.9	0	.3	.3	1.2
India	1.0	0	0	0	1.0	.1
Total	11.2	14.6	10.8	18.6	22.1	33.3

[1]Values in this table are obtained from the equation:
$S = F * E$, where:
S (million tons) is the portion of the average annual change in domestic production that is transferred to the world market; F is the fraction of the annual change in domestic production that is absorbed by changes in net trade volume (a_2 in tables 2 and 3), and E is the standard error of production from trend (from tables 2 and 3).
[2]Sum of columns 1 and 3 for 1960-77 and columns 2 and 4 for 1978-91.
[3]Note in table 2 that wheat trade was inversely related to production changes.
[4]The region is treated as one country.

Union's potential for transmitting instability was high even though stocks absorbed most of its production shocks. Conversely, although wheat production variability in Argentina was not as high as in some of the other top producing countries, the potential for Argentina to transmit instability was still quite high, largely due to the substantial portion of production variation that trade adjustments absorbed.

U.S. coarse grain and wheat production variability increased dramatically after 1978. Although a small percentage of this variability was exported to the world coarse grain market, highly variable production made the United States an important source of potential market instability. As mentioned earlier, however, this observation needs to be tempered by the fact that domestic stock levels have influenced U.S. production. To a certain extent, stock variability caused production variability. Despite their large volume of grain production, the EC and Eastern Europe exported relatively little production shocks. The main reason is that they had relatively small year-to-year deviations from trends in production.

Global evidence showed that stocks better stabilized levels of grain to the world's consumers after 1978. One possible explanation was that the major grain producing countries might have used carryover stocks to absorb more domestic production variability after 1977 than in previous years. If so, fluctuations in major grain producing countries' grain trade would absorb less of that variability; that is, less of the domestic production shocks would be exported onto the world market. The data in table 4, however, show that this is not the case. Among major grain producing countries, more production variability was transferred to the world market after 1977 than before. A notable exception was the EC-12, where less production variability was transferred to the world market. A second possible explanation was that since 1978, the grain stocks of major stockholding countries have been

more responsive to external shocks to the world market (that is, shocks that originated outside of those countries).

Relationship Between Domestic Stocks and World Price

Many countries wish to protect their domestic grain markets from world market variability. These countries can accomplish this by instituting policies that isolate their domestic grain market from the effects of world grain shortages or surpluses. Domestic stocks in countries following this strategy are perceived as being unresponsive to world prices. Their stocks therefore tend to provide no stability to the world market.

On the other hand, countries can manage stocks so that they are responsive to world grain prices, by accumulating stocks when the world grain price falls, and by drawing stocks down when the world price rises. This stocks response would tend to dampen world price fluctuations. Thus, a negative relationship between a country's grain stocks levels and international grain prices suggests that their stocks have a stabilizing effect on the world market.

Stocks Regression Equation

We used the following equation to measure the relationship between stocks and world price after eliminating the effects of trend:

$$S^{*} = a + bP^{*} + e,\ S^{*} = S - \underline{S},\ P^{*} = P - \underline{P}, \qquad (4)$$

where S is ending stocks, $\underline{S}$ is trend-ending stocks, P is the annual average MY wheat or corn (used for coarse grain) price at U.S. gulf ports, and $\underline{P}$ is trend price. Deviations from trend (S^{*}, P^{*}), rather than year-to-year changes, in the regression equation remove the effects of trend in the analysis. A statistically significant negative coefficient on the price variable suggests that a country's stocks tend to have a stabilizing effect on the world market price. This equation was estimated for each of the major grain stockholding countries or regions. Results for wheat and coarse grains are presented in tables 5 and 6.

Stocks and World Price Stability Results

Three major points are drawn from the regression results shown in tables 5 and 6. First, stocks of wheat and coarse grains appear to be a much more stabilizing force on world markets after 1977 than before. The simple regression for world wheat stocks since 1977 shows that stocks decreased 0.85 million tons for each U.S. dollar increase in the per ton wheat price. For 1960-77, the relationship between world wheat stock levels and world price was not as strong. Price responsiveness of world coarse grain stocks was also much higher after 1977.

Second, the United States was the major source of the world's price-responsive stocks since 1977. The U.S. stocks coefficient for wheat was about 40 percent of the world total (-0.349 compared with a world total of -0.852). The U.S. coarse grains stocks coefficient accounted for most of the world total.

The U.S. results for 1978-91 are consistent with results from other studies; that is, the United States tends to hold a very large share of the world's buffer stocks of grain. As Sharples and Goodloe (1984) and Sharples and Krutzfeldt (1990) explain, domestic grain policy objectives, not world price stabilization objectives, tend to drive U.S. stocks levels. The domestic agricultural community tends to view grain stockpiles as undesirable (Sharples and Krutzfeldt). Still, the end result is that U.S. grain stocks provided substantial stability to world grain markets.

Third, after being a destabilizing force in the world grain markets prior to 1978, EC grain stocks thereafter became a significant stabilizing force. During 1960-77, EC wheat and coarse grain stocks were positively correlated with world price, evidence that they were a destabilizing force on the world wheat market. Since 1977, grain stocks in the EC have exhibited a significant negative (stabilizing)

Table 5--Relationship between wheat stocks and world wheat price by leading stockholding countries

Country or region	Average stocks		Price coefficient[1] (a_1)	
	1960-77	1978-91	1960-77	1978-91
	-------Million tons--------		----------Coefficient----------	
United States	24.1	31.1	-0.078	-0.349[2]
Rest of world[3]	63.7	107.2	-.138	-.503[2]
China	9.9	29.0	.034	-.053
Former Soviet Union	11.9	18.8	-.024	-.129
EC-12	8.6	14.1	.025[2]	-.089[2]
India	4.5	9.6	-.032	-.115[2]
Canada	14.5	9.8	-.120[2]	-.092[2]
Australia	2.2	4.0	-.025	-.021
Turkey	1.8	4.2	-.012	0
Eastern Europe	1.4	1.5	-.003	.010
Argentina	.9	.6	.002	-.003
South Africa	.4	.5	-.001	.001
Mexico	.2	.3	.001	0
World	87.8	138.3	-.216	-.852[2]

[1] $S = a_0 + a_1P$, where S is annual detrended stocks, and P is annual detrended U.S. gulf free on board (f.o.b.) hard red winter (ordinary) wheat price in U.S. dollars per ton.
[2] Significantly different from zero at the 5-percent level of significance.
[3] World excluding United States.

relationship with price. Though the estimated coefficients are small, this appears to be a significant change in behavior.

The EC stocks response of recent years is a new stabilizing force on the world grain market. The significant negative relationship between EC stocks levels and world price for 1978-91 is especially noteworthy, because the EC grain markets have remained insulated from world prices. The change in EC stocks management patterns appears related to the EC becoming a large grain exporter. In the 1960's and 1970's, the EC was a net importer that turned to the world market in response to supply needs, especially for coarse grains, as indicated by the trade coefficients (tables 2 and 3). As EC exports rapidly expanded in the late 1970's and 1980's, government export subsidies were provided to make up the difference between high internal support prices and the world price. Apparently, when world prices fell, some grain tended to be stored rather than exported by the EC in order to hold down the high cost of export subsidy payments.[10] At higher world prices, stocks could be drawn down and exported with lower export subsidies. Hence, domestic budget considerations probably caused the more recent stabilizing effect on world prices of EC stock adjustments.

India's and Canada's wheat stocks in recent years also helped to stabilize world price. The size of Canada's stocks response, however, was relatively small.

[10] Political pressure on the EC from other countries to not subsidize exports also may have played a role.

Table 6--Relationship between coarse grain stocks and world coarse grain price by leading stockholding countries

Country or region	Average stocks		Price coefficient[1] (a_1)	
	1960-77	1978-91	1960-77	1978-91
	--------Million tons--------		----------Coefficient----------	
United States	44.3	76.3	-0.190	-1.748[2]
Rest of world[3]	52.6	79.2	.090	-.071
China	15.2	26.5	.112[2]	.112[2]
EC-12	7.3	12.0	.036	-.077[2]
Former Soviet Union	6.4	8.0	.016	-.049
Canada	5.5	5.6	-.020	-.031
Eastern Europe	1.9	4.2	-.009	-.030
Mexico	.8	1.5	.008	.036[2]
South Africa	1.3	1.4	.001	.016
India	4.7	1.3	-.044[2]	.017
Turkey	.4	.9	-.009[2]	-.005
Argentina	.5	.6	.006	-.002
Australia	.6	.5	-.015[2]	0
World	96.9	155.5	-.100	-1.819[2]

[1]$S = a_0 + a_1P$, where S is annual detrended stocks, and P is annual detrended U.S. gulf free on board (f.o.b.) corn price (no. 2) in U.S. dollars per ton.
[2]Significantly different from zero at the 5-percent level of significance.
[3]World excluding United States.

Conclusions

This study examines the role of each of the major grain producing countries--that are also the major holders of grain stocks--in generating instability or providing stability to world grain markets by how they manage their own stocks. The rules determining how grain stocks are managed vary among countries. In this study we do not examine those rules. Rather, we examine actual stock adjustments. An examination of the effects of specific policies on stockholding behavior in various countries should be the subject of further research.

Earlier economic studies of world stocks, based on data from the 1960's and 1970's, concluded that world grain price variability was excessive due to suboptimal management of the world's grain stocks. Results from this study indicate, however, that in more recent years world stocks have better performed their function of adding stability to world grain markets. World grain markets appear to be doing a better job than earlier in allocating the world's grain from one year to the next. Evidence of this is (1) less year-to-year variability around trends in global grain consumption, even though world production variability has increased and (2) less variability of season average world grain prices. These observed improvements occurred despite actions by most major grain producing countries to stabilize domestic grain markets at the expense of the world market.

Individual countries control and manage the world's grain stocks. There is no explicit global strategy. To understand how the world's stocks are managed, one needs to examine the performance of grain stocks held by countries that hold most of the world's stocks, which also are the world's major producing countries. A country's stocks can contribute to world grain market stability in two ways:

Table 7--Summary of absorption effects in selected countries or regions for wheat and coarse grains, 1960-77 and 1978-91[1]

Country or region	Coarse grains		Wheat	
	1960-77	1978-91	1960-77	1978-91
United States	None	Stabilizing	None	Stabilizing
Rest of world[2]	None	None	None	Stabilizing
China	Destabilizing	Destabilizing	None	None
Former Soviet Union	None	None	None	None
EC-12	Destabilizing	Stabilizing	Destabilizing	Stabilizing
Canada	None	None	Stabilizing	Stabilizing
Eastern Europe	None	None	None	None
India	Stabilizing	None	None	Stabilizing
Turkey	Stabilizing	None	None	None
Argentina	None	None	None	None
Australia	Stabilizing	None	None	None
South Africa	None	None	None	None
Mexico	None	Destabilizing	None	None

[1]If the price regression coefficient in the stocks equation is not significant at the 5-percent level (tables 5 and 6), the country is presented here as having no absorption effect.
[2]World excluding the United States.

(1) By offsetting part of the year-to-year variability of the country's own grain harvests (that is, by not exporting the entire shock in its domestic production variability onto the world market) and

(2) By offsetting part of the aggregate surpluses or shortages on the world market (that is, by releasing stocks when world prices were high and accumulating stocks when prices were low).

We used these two approaches to examine yearend stock levels in the major grain stockholding countries. Stocks adjustments after 1977 were compared with adjustments from 1960 to 1977 to see if behavior changed from that observed in earlier years.

We discovered that (1), above, has not been a source of added stability to the world grain markets since 1977. We did, however, find substantial improvement in the price responsiveness of grain stocks in several important countries (table 7). Thus, (2), above, appears to have been a significant source of increased stability in world grain markets in recent years.

Results of this study verified the conclusion of previous studies that stocks (private and public) in the United States provided a major stabilizing force on world grain markets. The variability of grain production in the United States was very large after 1977. The effects of that variability on the world grain markets, however, need to be interpreted with caution. Stocks adjustments and production

adjustments tended to be jointly determined; that is, government programs would cut production when beginning stocks were large. Still, a rather small fraction of production variability was transferred to the world market in the form of variability of trade volume. Further, U.S. stocks were very responsive, in a stabilizing way, to world grain price movements.

Previous studies suggested that the United States bore most of the direct costs of stabilizing world grain markets because the United States held most of the world's market-stabilizing stocks. Since 1977, this conclusion has appeared to be strongly supported in the world coarse grains market. But one can also argue that the very large variability of coarse grain production in the United States since 1977 has justified having the United States bear a large share of those costs.

The former Soviet Union is a major potential source of instability to world grain markets. Historically, that nation has experienced very large fluctuations in production. Substantial wheat stocks have been maintained and have provided considerable protection to domestic consumers against poor harvests. Thus, domestic wheat stocks have reduced the potentially destabilizing effects of the Soviet production variability on the world wheat market. On the other hand, stocks have not offset much of the domestic variability of coarse grain production.

The restructuring of the Soviet Union could have a significant effect on the stability of world grain markets. The variability of their grain production likely will not decrease. But decisions by grain producers and the governments will determine whether domestic stock adjustments will offset more or less of the Soviet Union's large production variability. In addition, if the Soviets hold more price-responsive stocks, additional stability will be added to the world market.

Argentina also is a major potential source of instability to world grain markets. Although production variability in Argentina has been smaller than in the United States or the former Soviet Union, Argentina passed on that variability to the world grain market. Few stocks were carried, and no measurable adjustments appeared to be made in domestic grain stocks to provide any stability to world grain markets.

Stock adjustments made in the EC in recent years appear to contribute significantly to world grain market stability. This is a surprising conclusion that differs from earlier years when EC stocks were a destabilizing force on world markets.

Canada's stocks have been a stabilizing force in the world wheat market for many years. Since 1977, India's wheat stocks also have appeared to add some stability (table 7).

Recent policy changes by the United States could lead to its playing a reduced role in damping the variability of prices on world grain markets. The 1990 Farm Act allowed grain price supports to be set closer to the low end of world market price fluctuations. The Act also downsized the farmer-owned reserve. These changes increased the market orientation of U.S. grain policy and reduced the likelihood of grain accumulating in government stocks. The quantity of stocks held by the private sector would be expected to increase and partially offset the expected reduction of government stocks. Other things equal, however, these market-oriented changes in policy will likely result in smaller U.S. grain stocks, and a reduced role of the United States in damping world price variability.

Would a future world of liberalized trade exhibit less variability or more variability of world grain prices than the world has experienced since 1978? Conventional economic wisdom is that liberalizing trade would add stability to world grain markets and increase their efficiency (Johnson, 1975). But well-functioning, efficient, world grain markets may not exhibit less world price variability than observed in recent years. With more market-oriented farm policies in the major grain stockholding countries, fewer stocks likely would be held--especially by the United States. The damping effect of stocks on fluctuations of world grain prices would be reduced. More research is needed to test whether trade liberalization might lead to a reduction in year-to-year variability in world grain prices, compared with that observed in recent years.

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U.S. Department of Agriculture
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SUMMARY OF REPORT

Central and Eastern European Agriculture Adapts to Open Markets

Number 10, February 1993

Contact: Jason Lamb, (202) 219-0620

Central and Eastern European (CEE) agriculture underwent dramatic change during the last 3 years. The introduction of market pricing, open borders, and increased freedom of entry and exit for firms occurred without the institutional and legal structures necessary for a market economy. Progress varies widely by country, but the northern countries of Poland, Hungary, and the Czech and Slovak Republics are much further along than the southern countries of Bulgaria, Romania, and Yugoslavia. The effect of market reforms on agriculture is documented in the 76-page report, *Agricultural Policies and Performance in Central and Eastern Europe, 1989-92* (FAER-247).

Many CEE countries shifted from pre-reform tight agricultural supplies or outright shortages to post-reform surpluses. Food availability and diversity have increased appreciably. Food prices have risen in nominal terms, but generally have lagged behind the overall inflation rate, reducing the prices of many food items relative to other goods and services.

But, farm financial performance has been poor. Food prices have risen, but less than farm input prices. Many issues regarding land and asset ownership in the farm sector remain unresolved, leading to uncertainty for planting and production. Consumer demand for agricultural products is depressed due to the sudden rise in consumer prices, while nominal income growth has been restricted through wage/pension caps. In addition, where the farm sector previously enjoyed unlimited demand for its products, it now faces stiff competition from a wider array of consumer products.

U.S. Export Opportunities

The value of U.S. agricultural exports to CEE countries dropped in 1991 due to the CEE's lack of hard currency needed to buy U.S. agricultural products and, more important, the CEE surplus of agricultural products from lower domestic demand and bumper grain harvests. U.S. agricultural exports of $225.3 million in 1991 were well below the 1990 level of $536.2 million. The level of U.S. agricultural exports has been bolstered by food aid granted to the CEE area, especially to Romania. CEE markets should stabilize and diminish the need for food aid.

Long-term export opportunities exist for U.S. agricultural inputs, machinery, and processing facilities, as well as soybeans and meal, cotton, tobacco, rice, certain specialty foods (nonindigenous fruits and fruit products, nuts), and consumer-ready foods. In addition, U.S. expertise in financing, farm management, and food processing is needed in the CEE countries. More short-term food aid may be needed in Albania, Romania, and some of the former Yugoslav republics.

Agricultural Production Steady as Domestic Demand Drops

The problems faced by the CEE agricultural sector had a smaller impact on production in 1991 than economists expected. Gross agricultural production in the region declined by 4.9 percent compared with 1990. Production levels in 1991 for most grains exceeded their 1986-90 averages, while many livestock and oilseed products fell below their 1986-90 levels.

To Order This Report...

The information presented here is excerpted from *Agricultural Policies and Performance in Central and Eastern Europe, 1989-92*, FAER-247, by Nancy J. Cochrane, Robert B. Koopman, Jason M. Lamb, Mark R. Lundell, Michele de Souza, and Danielle Sremac. The cost is $12.00 per copy.

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SUMMARY OF REPORT

Production Costs for Ethanol to Drop as New Technology Comes On-Line

Number 7, February 1993

Contact: Neil Hohmann (202) 219-0428

The fuel ethanol industry is poised to adopt a wide range of technologies that would reduce costs at every stage of the production process. Adoption of improved enzymes, fermenter designs, membrane filtration, and other innovations in the next 5 years is expected in new ethanol plants constructed to meet new demand resulting from Clean Air Act stipulations for cleaner burning fuel. A new report, *Emerging Technologies in Ethanol Production*, examines the likelihood of near- and long-term cost reductions in producing ethanol, as well as the potential of biomass (agricultural residues, municipal and yard waste, energy crops like switchgrass) to supplement corn as an ethanol feedstock.

Ethanol Industry Expands, Reducing Costs

The use of ethanol as a fuel for vehicles in the United States grew from insignificance in 1977 to nearly 900 million gallons in 1991. The ethanol industry emerged through a combination of government incentives and new technologies, which enabled large-scale production of ethanol from domestic resources, particularly corn. Growing consumer acceptance of ethanol-blended fuels, incentives to gasoline blenders, and falling costs of production (from $1.35-$1.45 per gallon in 1980 to less than $1.25 per gallon in 1992) were responsible for the jump in ethanol production.

The construction of new ethanol production plants and the adoption of new technologies at existing plants is likely to lead to further cost reductions (5-7 cents per gallon over the next 5 years). Improved yeasts, which tolerate high concentrations of ethanol, can lower energy costs. A system of membranes can recycle enzymes and capture high-value coproducts at many steps in the production process.

Longer term technologies would save approximately 9-15 cents per gallon over present costs. Energy and feedstock savings will result from technology that can convert some of the nonstarch portions of corn to ethanol. Development of microorganisms that speed the process will contribute to long-term savings. Development of markets for coproducts of ethanol production will create additional savings. Cost savings may be less for smaller plants that serve niche markets, or in older plants that must replace inefficient equipment.

Ethanol From Biomass Reduces Costs and Environmental Waste

Biomass can also be converted to ethanol, although commercial-scale ventures are limited by current technology. While biomass requires more handling and sorting before conversion, those costs may be offset by the abundance of biomass relative to corn. Although the production of ethanol from biomass is presently constrained by technological difficulties, new developments in this decade may allow ethanol to be produced from biomass at or below the cost of corn-derived ethanol.

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SUMMARY OF REPORT

1991 Net Farm Income Third Highest On Record

Number 9, February 1993

Contact: Cheryl Johnson, (202) 219-0804

Net farm income in 1991 was $44.6 billion, the third highest on record, trailing only 1989 and1990. The decline came about because production expenses were about the same as 1990 while prices and production for most commodities were down.

The decline was split pretty evenly between livestock and crops. Reduced sales of livestock and products reduced net farm income by $3.2 billion, largely because of a $2.1-billion decline in sales of dairy products. The decline due to crops came about chiefly because of a drawdown in inventory (that is, more crops were taken out of storage than were put in. Value of inventory is one component that goes into the overall net farm income measure).

To obtain a more complete picture of the status of the farm sector, the recently published ERS report, ***Economic Indicators of the Farm Sector: National Financial Summary, 1991,*** looks at several measures of farm income and balance sheet accounts:

Net farm income dropped 12.5 percent, triggered by a decline in gross farm income while production expenses remained about the same. Net farm income is an approximate measure of the farm's net value of production in the year. It includes all income and expenses, both cash and noncash, associated with the farm business and onfarm dwellings. It also measures the accounting profit from current-year production of commodities, and the value of services generated by dwellings located on the farm.

Net farm income

Year	Net farm income
	Billion dollars
1970	14.4
1975	25.5
1980	16.1
1985	28.8
1989	49.9
1990	51.0
1991	44.6

Returns to operators, which differs from net farm income by excluding all income and expenses related to operator dwellings, declined 12.7 percent to $43.2 billion.

Net cash income was down 5.4 percent to $58 billion, after setting records in each of the previous 6 years. This drop was due almost entirely to a decline in Government payments and lower receipts from the sale of dairy products. Net cash income measures cash earnings that farmers receive during the year from their farm business.

Farm equity dropped 1 percent as the value of farm assets declined, and outstanding debt increased. Farm debt increased for the first time since 1984, up $2 billion from 1990 to $139 billion. Real estate debt rose to $74.4 billion, up $700 million, and nonreal estate debt increased to $64 billion, up by over $1.2 billion.

The ***debt-to-asset ratio*** rose from 16.2 to 16.5 percent, the second lowest level of farm business debt relative to assets in the past 15 years. This ratio is a good method for assessing overall financial risk by measuring debt pledged against farm business assets.

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